A2575-30F

12/93

RCRA ECONOMIC IMPACT ANALYSIS: REFINERY NONHAZARDOUS WASTEWATER SURFACE IMPOUNDMENTS

RESEARCH STUDY #072
SEPTEMBER 1993

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1220 L Street, Northwest
Washington, D.C 20005

RCRA Economic Impact Analysis: Refinery Nonhazardous Wastewater Surface Impoundments

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Research Study #072

September 1993

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Table of Contents

I. Introduction and Summary 1

II. Surface Impoundment Acreage Survey 3

III. RCRA Reauthorization Scenarios and Impacted Facilities 5

IV. Estimated Unit Costs of Compliance Options 11

V. Estimated Choice of Compliance Options 15

VI. Estimated Costs for U.S. Petroleum Refiners 19

VII. Sensitivity Analysis 25

VIII. Conclusions 29

Appendixes

A. RCRA Reauthorization Scenarios for New and Existing Impoundments 31

B. Detailed Cost Estimates for Scenarios 35

List of Tables

Table 1: Survey and Estimated Refinery Nonhazardous Wastewater Impoundment Acreage 4
Table 2: RCRA Reauthorization Scenarios for Existing Impoundments 7
Table 3: Matrix of Regulatory Requirements Under Three RCRA Reauthorization Scenario 9
Table 4: Estimated Unit Costs of Compliance Methods 12
Table 5: Percent Conversion of Existing Impoundment Acreage to Liner and Tank Option 17
Table 6: Cost Analysis Assumptions 20
Table 7: Estimated Costs to the U.S. Petroleum Refining Industry 21
Table 8: Sensitivity Analysis: Present Values of Total Industry Costs 27
Table 9: Sensitivity Analysis: Percentage Changes in Costs From Base Case 28

Table A1: RCRA Reauthorization Scenarios for New and Existing Impoundments 32
Table A2: Matrix of Regulatory Requirements for New and Existing Impoundments 34
Table B1: Estimated Present Value of Industry Costs - Scenario A 36
Table B2: Estimated Present Value of Industry Costs - Scenario B 37
Table B3: Estimated Present Value of Industry Costs - Scenario C 38

List of Figures

Figure 1: Assumed Distribution of Impoundment Acreage By Compliance Method 18
Figure 2: Present Value of Industry Costs by Type of Surface Impoundment 22
Figure 3: Present Value of Industry Costs by Compliance Option 23

Endnotes 39

References 39

Forward

The American Petroleum Institute's RCRA Reauthorization Task Force, Waste Program Group, and Health and Environment Subcommittee identified the management of nonhazardous wastewater in surface impoundments as one of several priority issues. It was determined that an economic analysis should focus on refinery nonhazardous surface impoundments and evaluate the cost implications of possible new laws and regulations impacting their use. This analysis summarizes the efforts of several groups with substantial public policy and operational experience relating to the refining sector, surface impoundments, and the Resource Conservation and Recovery Act (RCRA). These groups include API committees (such as the RCRA Reauthorization Coordinating Team and the Committee on Refinery Environmental Control), API staff, and contractors to API (Delta Analytical Corporation and ERM-Southwest, Inc). While the Policy Analysis and Strategic Planning Department is responsible for the analysis in this Research Study, many others contributed concepts, data, and pertinent technical information as well as many useful comments on preliminary drafts of the study. This report would not have been possible without their efforts.

I. Introduction and Summary

Refineries may use a variety of nonhazardous surface impoundments to treat materials generated by production processes. Some impoundments simply minimize physical movement and provide time for suspended material to separate from wastewater prior to disposal. Other impoundments involve much more complex processes. A biological surface impoundment, for example, may use an active mass of microbes to aerobically reduce organic matter from a wastestream.

Increasingly stringent regulatory requirements on the use of nonhazardous surface impoundments, such as might occur under a reauthorization of the Resource Conservation and Recovery Act (RCRA), could lead to modification of the surface impoundments or even their replacement with tanks. This Research Study summarizes available information on the direct cost implications of three different scenarios for possible new regulatory requirements on nonhazardous surface impoundments. The analysis is static in nature in that it estimates compliance costs to refiners, given the existing number of surface impoundments. It does not address potential process changes by refiners, the extent to which higher costs might be passed on to consumers in the form of higher prices, or any potential environmental benefits from the assumed regulatory scenarios.

This economic impact analysis has five major components, each of which are discussed in more detail below.

- Surface Impoundment Survey:

The American Petroleum Institute (API) and the National Petroleum Refiners Association (NPRA) conducted a survey of surface impoundments at U.S. refineries in late 1991. This impact analysis uses the results of the survey to estimate the universe of total U.S. petroleum refinery impoundment acreage (about 3,800 acres) that could be impacted by new surface impoundment requirements. The survey gathered information on various types of impoundments ranging from upstream biological impoundments to downstream clarifying/equalization/polishing impoundments

- Legislative/Regulatory Scenarios:

Three potential legislative/regulatory scenarios were developed to reflect a range of possible regimes for managing nonhazardous wastewater surface impoundments. The scenario effort sought to identify potential regulatory requirements for specific types of surface impoundments. These scenarios include technology requirements (to be met, for example, by lining impoundments or replacing them with above-ground tanks), notification requirements, and groundwater monitoring requirements. Potential requirements increase in stringency from scenario A to scenario B, and scenario C contains the most stringent requirements. For example, scenario C would require that certain types of surface impoundments meet liner requirements like those presently required for hazardous waste landfills.

- Unit Costs:

Different technical options were identified for meeting the various regulatory requirements. After the options were reviewed by industry experts, estimates were developed for the unit costs of these options. These estimates were made on a per acre of impoundment or per impoundment basis for each scenario and for each type of impacted surface impoundment. The technical options and unit costs were selected based on industry and consultant experience and professional judgement.

- Choice of Compliance Options:

Estimates were made of the percentages of surface impoundments that refineries would manage under different technical options. These estimates, which indicate a range of possible outcomes, were selected based on industry and consultant professional judgement taking into consideration the legislative and regulatory scenarios, the unit cost estimates for the technical options, and possible relative risks associated with the various technical options.

- Total U.S. Refining Cost Estimate:

The cost of each regulatory scenario was estimated for the universe of petroleum refinery nonhazardous wastewater surface impoundments by scaling up the unit cost estimates using the estimated choice of compliance options.

Based on this work and other assumptions discussed below, this study finds that potential new requirements on nonhazardous wastewater surface impoundments could result in significant compliance expenditures.

Scenario A is estimated to have an initial cost of about $3.4 billion plus annual costs of $117 million. Using a 10 percent discount rate and a time horizon of 30 years, this is equivalent to an annualized cost of $475 million and a present value cost of about $4.5 billion.

Scenario B is estimated to have an initial cost of about $3.7 billion plus annual costs of $129 million. This is equivalent to an annualized cost of $520 million and a present value cost of $4.9 billion.

Scenario C is estimated to have an initial cost of about $5.5 billion plus annual costs of $190 million. This is equivalent to an annualized cost of $772 million and a present value cost of $7.3 billion.

The estimated annualized costs, ranging from $475 million to $772 million per year, are substantially above the $100 million per year criterion used to identify a "major" rulemaking that would require a regulatory impact analysis under Executive Order 12291. Initial costs, as opposed to annual operation and maintenance costs, account for the majority of compliance expenditures that would be incurred.

Two types of impoundments (clarifying, equalization and polishing impoundments, and contaminated stormwater impoundments) account for a large share of total costs. Two types of compliance options account for a significant share of total costs because of their widespread use: replacement of impoundments with tanks, and the installation of certain types of liners. As discussed below, these results are insensitive to changes in most unit costs and changes in other factors as well. In addition, relative total costs under scenarios A, B, and C are insensitive to changes in most assumptions.

In some cases, the assumed regulatory requirements may result in replacing impoundments with tanks for processing wastewater. The potential closing of impoundments raises the question of possible corrective action to clean up soil underneath any surface impoundments that have leaked wastewater. Because of uncertainty over the extent of contamination, and because of other research efforts examining corrective action at refineries, it was determined that potential costs of corrective actions would not be addressed in this impact analysis. Additionally, the analysis was directed at identifying the cost implications for new requirements on existing impoundments, rather than the implications for new impoundments, because it appeared likely that few, if any, petroleum refiners will install new surface impoundments in the future.

II. Surface Impoundment Acreage Survey

The American Petroleum Institute and the National Petroleum Refiners Association undertook a surface impoundment acreage survey in late 1991, and the survey data were complied early in 1992. The survey, which requested estimates of surface impoundment acreage by type of impoundment, was sent to refineries owned by member companies of the API as well as NPRA. The survey covered nonhazardous wastewater impoundments (for which influent is contaminated but passes TCLP), other nonhazardous wastewater impoundments (with influents not contaminated), and RCRA Subtitle C TSD impoundments (which contain hazardous material). Since this analysis focuses on nonhazardous wastewater impoundments and excludes hazardous impoundments,[1] only the results for the two categories of nonhazardous impoundments are included in this analysis.

The results of the survey are summarized in Table 1. A total of 2,622 acres of nonhazardous wastewater impoundments were reported. The single largest category was clarifying/equalizing/polishing impoundments, which accounted for 67 percent of reported nonhazardous wastewater impoundment acreage. Not all refineries had all types of impoundments, and the acreage of a given type of impoundment at any given refinery ranged from 0.1 acres to 678 acres.

The survey was returned by 109 out of approximately 200 U.S. refineries. These 109 refineries account for about 12.0 million barrels per stream day of refining capacity, or about 69 percent of the 17.4 million barrels per stream day of total[2] refining capacity (including capacity in Puerto Rico and the Virgin Islands) reported in the Energy Information Agency's *Petroleum Supply Annual 1991* for January 1, 1992. To estimate the universe of nonhazardous wastewater surface impoundments at U.S. refineries, it was assumed that the ratio of acres of surface impoundments to refinery capacity was the same for refineries not responding to the survey as it was for the refineries that did respond. Under this assumption, there are an estimated 3,811 acres of nonhazardous wastewater surface impoundments at U.S. refineries. The estimated universe of impoundments, by impoundment type, is shown in Table 1.

Table 1

Survey Results and Estimated Universe of Refinery Nonhazardous Wastewater Impoundment Acreage

Impoundment Type	Survey Results # Refineries	Survey Results # Acres	Estimated Universe # Acres
Upstream:			
Biological	29	143.0	207.8
Other Upstream:			
Contaminated Stormwater	38	481.0	699.0
Settling Ponds	23	61.8	89.8
Other Nonhazardous	12	173.7	252.4
Downstream:			
Clarify/Equal/Polish	37	1,763.0	2,562.2
Total	74	2,622.5	3,811.3

Note: Survey results are from a February 12, 1992 summary of the API and NPRA surface impoundment acreage survey. The survey had 109 responding refineries accounting for 12.0 million barrels per stream day of refining capacity. The universe of impoundments was estimated using Energy Information Administration's *Petroleum Supply Annual 1991* data reporting U.S. total refining capacity as 17.4 million barrels per stream day (including Puerto Rico and the Virgin Islands) as of January 1, 1992.

III. RCRA Reauthorization Scenarios and Impacted Facilities

The impact of a RCRA reauthorization that more stringently regulates nonhazardous surface impoundments could vary substantially depending on the nature of new technical requirements and the cost of implementing those requirements. The potential implications of different degrees of stringency can be assessed by 1) developing regulatory scenarios that assume different sets of realistic requirements, and 2) estimating the costs of implementing each scenario. Legislative scenarios covering nonhazardous wastewater surface impoundments were developed to cover a range of increasingly stringent requirements for the management of surface impoundments. Although the scenarios developed included requirements for new impoundments, the focus of this analysis is on existing impoundments, since it is expected that only a few, if any, petroleum refiners will install new surface impoundments in the future.[3]

Three scenarios were developed. Each would include requirements for retrofitting different types of impoundments with different types of liners in order to prevent the leaching of stored material into the environment. Two types of liners were evaluated:

- a "less than minimum technological requirements" (<MTR) liner, which consists of a three-foot layer of compacted low permeability soil (generally clay) that meets certain in-place saturated hydraulic conductivity requirements; and

- a "minimum technological requirements" (MTR) liner, which consists of the three-foot compacted clay liner, over which are placed a synthetic flexible membrane liner, a leachate detection/collection system, and a second synthetic liner. The assumed MTR liner design is based on current RCRA liner requirements for Subtitle C hazardous waste landfills.

The technical details of the liner assumptions are included in the ERM-Southwest, Inc. report to the American Petroleum Institute, "Study of Petroleum Refining Costs of Potential RCRA Reauthorization Requirements on New and Existing Industrial Solid Waste Surface Impoundments" dated October 27, 1992.

Scenarios A, B, and C are summarized in Table 2, and the requirements for the various types of impoundments are summarized in Table 3. As noted above, this analysis does not evaluate the impact of possible new regulations on any new impoundments that might be constructed. Appendix A contains scenario and requirement descriptions for new as well as existing impoundments.

Under scenario A, all existing surface impoundments receiving nonhazardous contaminated wastewater would be subject to notification and groundwater monitoring requirements. In the event that migration of contamination from an impoundment is detected, corrective action and a liner meeting "less than minimum technical requirement" performance standards would be necessary for the continued use of the impoundment. As noted earlier, corrective action costs are not included in this analysis.

Under scenario B, existing clarifying, equalization or polishing ponds downstream of biological treatment have the same requirements as under scenario A. However, in addition to the scenario A requirements, existing biological, contaminated stormwater, settling or other impoundments receiving nonhazardous contaminated wastewater would have to install a liner meeting "less than minimum technical requirement" performance standards whether or not migration of contamination from the impoundment was detected.

Under scenario C, existing clarifying, equalization or polishing ponds downstream of biological treatment continue the basic requirements under scenario A, but they also would be subject to "less than minimum technical requirement" performance standards. Under scenario C, the existing biological, contaminated stormwater, settling or other impoundments receiving nonhazardous contaminated wastewater would be subject to "minimum technical requirement" performance standards. In addition, the notification requirements under scenario C would include financial assurance.

TABLE 2

RCRA Reauthorization Scenarios* For Existing Nonhazardous Wastewater Surface Impoundments

A	B	C
o Existing biological, clarifying, equalization, polishing, contaminated stormwater, settling, and other impoundments receiving nonhazardous contaminated wastewater would be subject to notification and groundwater monitoring only, unless migration of contamination from the impoundment is detected and then: corrective action and <MTR requirements. It is assumed that where an impoundment has been completely removed through clean closure, no groundwater monitoring system will be installed.	o Existing biological, contaminated storm water, settling, and other impoundments receiving nonhazardous contaminated wastewater (except clarifying equalization or polishing ponds downstream of biological treatment; see below) would be subject to <MTR performance standards as defined under Column A plus corrective action if migration of contamination from the impoundments is detected. o Existing clarifying, equalization or polishing ponds downstream of biological treatment would be subject to notification and groundwater monitoring only unless migration of contamination from the impoundment is detected and then: corrective action plus < MTR requirements.	o Existing industry surface impoundments receiving nonhazardous contaminated wastewater (except existing, clarifying, polishing and equalization ponds downstream of biological treatment; see below) would be subject to MTR, notification, financial assurance, and corrective action. o Existing clarifying, equalization or polishing ponds downstream of biological treatment only would be subject to <MTR performance standards as defined under Column A plus corrective action if migration of contamination from the impoundments is detected.

* See end of table for notes.

TABLE 2 (Continued)

RCRA Reauthorization Scenarios* For Existing Nonhazardous Wastewater Surface Impoundments

A	B	C
o Impacted Facilities: Existing impoundments receiving contaminated wastewater (influent is not a characteristic or listed hazardous waste) would provide notification and conduct ground water monitoring only, unless migration of contamination from the impoundment is determined then, corrective action and <MTR requirements.	o Impacted Facilities: Impoundments receiving contaminated wastewater (influent is not a characteristic or listed hazardous waste) would meet <MTR, and/or notification and ground water monitoring depending on impoundment type, and corrective action if migration of contamination is determined.	o Impacted Facilities: Impoundments receiving contaminated wastewater (influent is not a characteristic or listed hazardous waste) would meet either MTR or <MTR depending on impoundment type, and corrective action if migration of contamination is determined.
o Non-Impacted Facilities: Existing units exempted under RCRA's wastewater treatment exclusion (those meeting the RCRA definition of "tank"). Existing impoundments receiving only uncontaminated influent (e.g., once through cooling water, uncontaminated stormwater, uncontaminated firewater).	o Non-Impacted Facilities: Existing units exempted under RCRA's wastewater treatment exclusion (those meeting the RCRA definition of "tank"). Existing impoundments receiving only uncontaminated influent (e.g., once through cooling water, uncontaminated stormwater, uncontaminated firewater).	o Non-Impacted Facilities: Existing units exempted under RCRA's wastewater treatment exclusion (those meeting the RCRA definition of "tank"). Existing impoundments receiving only uncontaminated influent (e.g., once through cooling water, uncontaminated stormwater, uncontaminated firewater).

NOTES:
* API's RCRA Reauthorization Coordinating Team oversaw development of the reauthorization scenarios.. There are an infinite number of possible scenarios.
* These represent three possible points within the spectrum in order to facilitate economic analysis.

TABLE 3

Matrix of Regulatory Requirements For Existing Surface Impoundments Under Three RCRA Reauthorization Scenarios

Type of Impoundment	Scenario A		Scenario B		Scenario C	
	Migrated Contamination	No Migrated Contamination	Migrated Contamination	No Migrated Contamination	Migrated Contamination	No Migrated Contamination
Nonhazardous Contaminated Liquids (a)	<MTR, GWM, *CA, N	GWM, N	<MTR, GWM, *CA, N	<MTR, GWM, N	MTR, GWM, *CA, N	MTR, GWM, N
Nonhazardous Contaminated Liquids Downstream of Biological (b)	<MTR, GWM, *CA, N	GWM, N	<MTR, GWM, *CA, N	GWM, N	<MTR, GWM, *CA, N	<MTR, GWM, N

NOTES: (a) Includes Biological, Contaminated Stormwater, Settling Ponds and Other
(b) Includes Clarifying, Equalization, and Polishing
MTR = Minimum Technology Requirements
<MTR = Less Than MTR Requirements
GWM = Ground water monitoring
CA = Corrective Action
N = Notification
NA = Not Applicable
* Permits may be required for impoundments subject to corrective action, but correction action and associated requirements and costs are beyond the purview of this study.

IV. Estimated Unit Costs of Compliance Options

API contracted with ERM-Southwest, Inc. to develop unit cost estimates (per acre or per impoundment) for ways of meeting the regulatory requirements assumed under each scenario. API provided ERM with the scenarios discussed above. Based on their extensive remediation experience, ERM identified options that refineries could use to meet the assumed regulatory requirements. These options include actions such as performing a liner equivalency demonstration, installing a liner meeting MTR or less than MTR performance standards, or using tanks to replace impoundments. After the options were reviewed by industry experts, ERM developed cost estimates for each option.[4] Table 4 summarizes the cost estimates made by ERM. A detailed description of the technical options and individual cost items is contained in the ERM-Southwest report.

The cost of a given option is assumed to be independent of the scenario (except for notification costs), but only certain options and costs are relevant for each scenario. For some options, unit costs estimates could be applied in a straight forward manner. Other options, however, entail multiple decisions and costs. For example, replacing a surface impoundment with an aboveground steel tank requires a decision on the disposition of the impoundment, such as idling the impoundment, closing the impoundment as a landfill and providing 30 years of post-closure care, or clean closing the impoundment.

As described in more detail below, idling an impoundment involves discontinuing flow to the impoundment, but not closing the impoundment. Any water accumulating in the impoundment from precipitation would be allowed to evaporate or flow out through a National Pollution Discharge Elimination System (NPDES) outfall. Closing as a landfill, required if all contamination is not removed prior to closure, includes placement of an engineering cap over the impoundment, plus groundwater monitoring and post-closure care (maintaining the engineering cap) for 30 years. Clean closing the impoundment requires excavation of all contaminated material (waste and soil) from the impoundment and disposal of the excavated materials.

The compliance options under all scenarios assume that all types of impoundments (with one exception, as noted below) would be subject to both groundwater monitoring and notification costs. ERM's estimate of groundwater monitoring and notification costs were:

- Groundwater Monitoring:

Under all three scenarios, all impoundments are assumed to be subject to groundwater monitoring except impoundments that are both replaced by tanks and clean closed. Groundwater monitoring is estimated to cost $31,000 per impoundment for installation of monitoring wells plus $13,500 per impoundment per year in monitoring costs. Impoundments that are landfill closed have an additional $7,200 per year in costs related to cap maintenance and reporting requirements.

- Notification:

All impoundments incur notification costs under all scenarios. Notification includes filing a report with appropriate state and/or federal authorities detailing the characteristics of the facility and surrounding areas (such as the number of local drinking water intakes downstream of the facility), and development of a waste minimization/pollution

Table 4

Estimated Unit Costs of Compliance Methods (1992 Dollars)

Compliance Method	Cost Per Acre Of Impoundment		Additional Cost Per Impoundment	
	Initial	Annual O&M	Initial	Annual O&M
Groundwater Monitoring	$0	$0	$31,000	$13,500
Notification:				
Scenarios A and B	0	0	15,000	0
Scenario C	0	0	35,000	0
No Liner Needed	0	0	0	0
Liner Equiv. Test	0	0		125,000
< MTR Liner	1,379,150	0		0
MTR Liner	1,619,150	34,000	0	0
Regular Tank System	727,000	82,000		0
Impoundment Disposition:				
Idle	0	0	0	0
Landfill Closure	718,740	0	0	7,200
Clean Closure	1,377,300	0	0	0
Activated Sludge Tank System	737,000	152,000	0	0
Impoundment Disposition:				
Idle	0	0	0	0
Landfill Closure	718,740	0	0	7,200
Clean Closure	1,377,300	0	0	0

Source: ERM-Southwest, "Study of Petroleum Refining Costs of Potential RCRA Reauthorization Requirements on New and Existing Industrial Solid Waste Surface Impoundments" (October 27, 1992).

prevention plan and groundwater monitoring plan. For scenarios A and B, notification is estimated to cost $15,000 per impoundment. For scenario C, a more detailed notification requirement plus financial assurance is estimated to cost $35,000 per impoundment.

Several options were evaluated for impoundments that continue in operation. The ability to select a given option would depend on the scenario and type of impoundment, as well as local conditions. The following options were considered:

• No Liner Needed:

Under certain scenarios and certain conditions (e.g. no migration of contamination from the impoundment), an impoundment might qualify for the "no liner needed" option, and no action or expenditures would be required.

• Liner Equivalency Test:

Under this option, it might be demonstrated that an impoundment, that otherwise would be required to have a liner, meets specified performance standards (usually because of certain geological and hydrological conditions) without the installation of a synthetic liner. The cost of the liner equivalency test is estimated at $125,000 per impoundment.

• <MTR or MTR Liner:

Alternatively, it may be necessary to modify the impoundment so that it meets either "less than minimum technical requirements" performance standards or "minimum technical requirements" performance standards. Both liner standards involve cleaning and preparation costs (including excavation and commercial nonhazardous landfill disposal of sludge and soil from the existing impoundment) estimated at $1,240,150 per acre. The <MTR performance standard assumes installation of a three foot thick clay liner. The <MTR liner retrofit costs are estimated at $139,000 per acre, plus cleaning and preparation costs, for a total initial cost of $1,379,150 per acre. The MTR performance standard assumes these same costs plus additional materials including two geomembrane liners and a leak collection system. The MTR liner retrofit costs are estimated at $379,000 per acre, plus cleaning and preparation costs, for a total initial cost of $1,619,150 per acre. An impoundment meeting MTR performance standards also is estimated to have operating and maintenance costs of $34,000 per acre per year.

Depending on the scenario and type of impoundment, companies may opt to replace existing surface impoundments with aboveground steel tanks. Under this option, costs would depend on the type of impoundment being replaced and the disposition of the surface impoundment. The cost estimates are given on a per acre of surface impoundment basis. The following options were considered:

• Activated Sludge Tank System:

The ERM study assumes that converting a biological treatment surface impoundment to an activated sludge tank would have an initial cost of $737,000 per acre of surface impoundment plus incremental annual operating and maintenance costs of $152,000 per acre of impoundment. In developing these figures, ERM estimated that there would be a 75 percent reduction in surface area when an aerated surface impoundment is replaced with an activated sludge system.

• Regular Tanks System:

Other types of impoundments would be converted to a less complex tank system estimated to cost about $727,000 per acre of impoundment plus annual operating and maintenance costs of $82,000 per acre. In developing these figures, ERM estimated that there would be a 15 percent reduction in volume when these types of surface impoundments are replaced with steel tankage.

When an impoundment is replaced by an aboveground tank, a decision must be made as to how to manage the impoundments. Three management options were evaluated.

• Idle:

Idling an impoundment could involve discontinuing flow to the impoundment but not closing the impoundment, or using the impoundment to manage the flow from its replacement tank if it meets or nearly meets National Pollution Discharge Elimination System standards. ERM estimated that the costs of idling an impoundment would be negligible for most refineries.

• Landfill Closure:

Closing the impoundment as a landfill involves stabilizing any contamination, capping the impoundment, and performing groundwater monitoring

and 30 years of post-closure care. This option is estimated to have initial costs of $718,740 per acre for stabilizing and capping the impoundment plus additional groundwater monitoring costs. The initial installation of groundwater monitoring wells and monitoring equipment costs was identified above ($31,000 per impoundment), but 30 years of post-closure care is estimated to cost an additional $20,700 per impoundment per year ($13,500 as for other impoundments plus $7,200 per year for cap maintenance, etc.).

- Clean Closure:

Clean closing an impoundment involves removing and disposing of impoundment waste and any contaminated soil, and backfilling the impoundment. Clean closing is estimated to have an initial cost of $1,337,300 per acre, with no additional costs for groundwater monitoring or post-closure care. Clean closing an impoundment is assumed to remove the source of potential groundwater contamination and therefore eliminate the need for groundwater monitoring.

V. Estimated Choice of Compliance Options

As described above, the ERM report identified a number of options for handling contaminated but nonhazardous wastewater currently managed in petroleum refinery impoundments. These include the no liner needed case, a liner equivalency demonstration, installation of a liner meeting less than MTR performance standards, installation of a liner meeting MTR performance standards, or installation of a tank to replace the impoundment. If the last option is chosen, the impoundment would be idled, landfill closed, or clean closed. There is substantial uncertainty about the choices refiners would make between the options for managing existing impoundments if faced with the requirements in scenarios A, B, or C. As a result, there is substantial uncertainty regarding the percentage of existing nonhazardous surface impoundments that would be managed in a particular manner under a given scenario.

A number of factors likely would influence choices made among the management options. Of primary importance would be the specific legislative scenarios and the estimated costs of meeting the technical requirements of subsequent regulations.[5] For a given type of impoundment, the choice of a compliance option also may depend on local geological and hydrological conditions, the potential that contamination from the impoundment may have migrated to groundwater, and characteristics of nearby property. For example, local geological and hydrological conditions would determine the likelihood that any material released from an impoundment could impact groundwater or migrate from the general location of the impoundment. Similarly, the extent of potential damage and refinery liability due to any migrating contamination would depend in part on the ownership and use of nearby property.

Another element of uncertainty relates to disposal of material removed from an existing nonhazardous wastewater impoundment. Sludge and/or soil may have to be removed from an impoundment if a new liner is installed (to meet either <MTR or MTR performance standards) or if the impoundment is clean closed. And depending on the nature of the impoundment and cap design, material also may have to be removed when an impoundment is landfill closed.

Even though the material being disposed of may be classified as contaminated but nonhazardous, disposal carries with it potential future liability. In many respects, disposal off-site at a facility meeting all current regulatory requirements may carry greater uncertainty over future liability than capping the impoundment in place or disposing of the material on-site. For example, proper disposal in an off-site landfill could give a refiner potential liability as a "potentially responsible party" under the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) if others inappropriately dispose of material in that same landfill. Hence, the threat of uncertain liability under current or future laws could cause a refiner to choose an option that does not appear to be a least cost approach in this analysis, but could be economically rational when the potential costs of uncertain future liability are considered.

Whether contamination of groundwater is known or suspected is another uncertainty. For example, only notification and groundwater monitoring are assumed under scenario A, unless migration of contamination from the impoundment is detected, and then corrective action and <MTR performance standards are required for continued use of the

impoundment. The choice among management options may be influenced by known or suspected contamination in the general area of the impoundment (perhaps based on information from other monitoring wells at the facility), even before groundwater monitoring for the specific impoundment in question is put in place. If contamination is known to exist, it may not be known whether the contamination is the result of current or past releases, and it may be effectively impossible to identify a specific source. As a result, some refiners might choose to install liners or tanks as a precaution because it might not be possible to prove that an impoundment is not releasing material (i.e., that known or suspected contamination is unrelated to a specific impoundment).

The assumed choices among compliance options from Tables 4, 5, and 6 of ERM's report are summarized here in Table 5. These choices reflect the combined experience and judgement of ERM staff, through their remediation work, and industry experts, through their refinery experience. Combining the assumed compliance choices and the estimated universe of nonhazardous impoundment acreage yields Figure 1, the distribution for each scenario of the estimated universe of nonhazardous wastewater impoundment acreage among the management options. As noted above, estimates of the choice among compliance options must be viewed as qualitative in nature rather than quantitative, despite the presentation of the choices in a quantitative manner.

Under scenario A, it is assumed that 75 percent of biological surface impoundment acreage will have contaminated groundwater and that these impoundments would be replaced by tanks and lined impoundments. (ERM notes that this 75 percent assumption is speculative "...because no information on the actual percentage is available. The assumption is intended to be used for the purpose of comparing scenarios only and should not be used in any other context.") ERM concludes that few refineries will chose to prepare a liner equivalency demonstration because "...experience has shown that these demonstrations are not often approved." For contaminated stormwater impoundments, settling ponds and other nonhazardous impoundments, it was assumed that 15 percent would not have contaminated groundwater and therefore would not have a liner requirement. According to ERM, "these percentages are based on very limited experience and are therefore speculative." For clarifying, equalization, and polishing impoundments, it was assumed that 55 percent would exhibit groundwater contamination and generally be replaced by impoundments with <MTR liners or tanks. Overall under scenario A, about 36 percent of acreage utilizes the "no liner" option, 28 percent have a <MTR liner installed, and 31 percent are converted to regular or activated sludge tanks.

ERM's report (pages 4-6) specifies similar underlying assumptions regarding factors impacting the selection among alternative compliance options under scenarios B and C. Under scenario B, about 5 percent of the acreage moves from the "no liner" category into either the <MTR liner option or a tank option. Under scenario C, the "no liner" option is no longer used, and about 36 percent of the acreage has <MTR liners, 9 percent has MTR liners, and about 50 percent is converted to tanks. In all scenarios, an estimated 5 percent of the acreage uses the "liner equivalency demonstration" option. As indicated in Table 5, the ERM report estimated that when impoundments are converted to tanks under any option, 10 percent of the impoundment acreage is idled, 60 percent is landfill closed (closure/post closure), and 30 percent is clean closed.

Table 5

Percent Conversion of Existing Nonhazardous Wastewater Impoundment Acreage To Liner and Tank Options

Scenario/Compliance Method	Upstream		Downstream
	Biological	Other*	C/E/P**
Scenario A:			
No Liner Needed	25	15	45
Liner Equivalency Demonstration	5	5	5
< MTR Liner	10	40	25
MTR Liner	0	0	0
Regular Tank ***	10	40	25
Activated Sludge Tank ***	50	0	0
Total	100	100	100
Scenario B:			
No Liner Needed	0	0	45
Liner Equivalency Demonstration	5	5	5
< MTR Liner	14	48	25
MTR Liner	0	0	0
Regular Tank ***	14	47	25
Activated Sludge Tank ***	67	0	0
Total	100	100	100
Scenario C:			
No Liner Needed	0	0	0
Liner Equivalency Demonstration	5	5	5
< MTR Liner	0	0	54
MTR Liner	15	30	0
Regular Tank ***	10	65	41
Activated Sludge Tank ***	70	0	0
Total	100	100	100

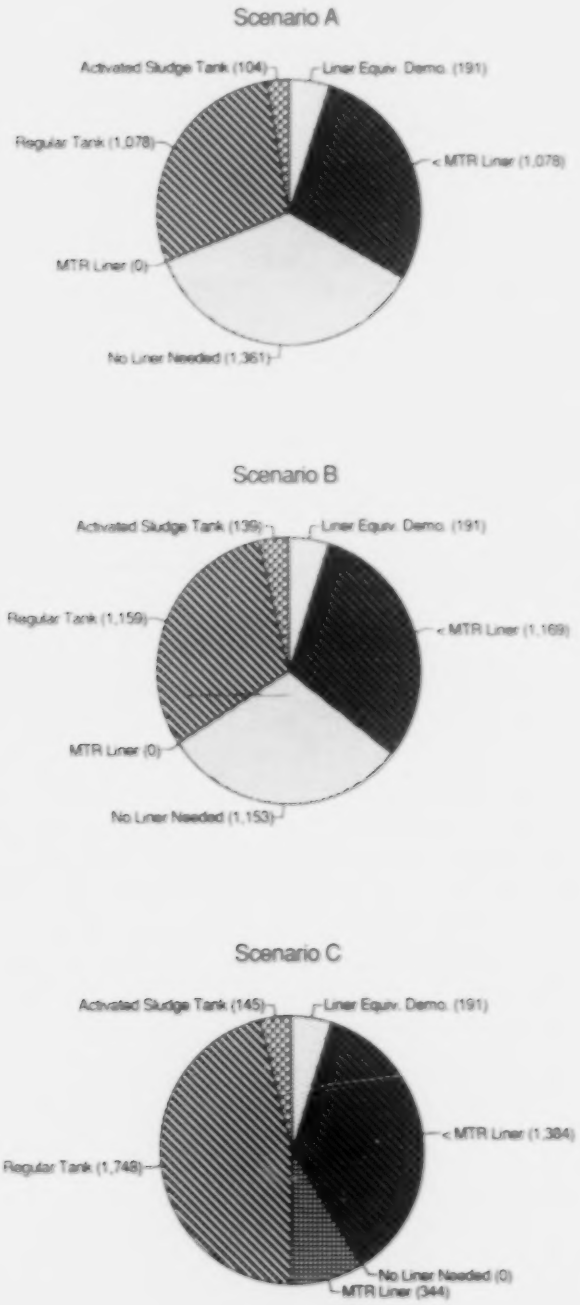
Notes:

* Includes Contaminated Stormwater, Settling Pond, and Other Nonhazardous impoundments.

** Includes Clarifying, Equalization, and Polishing impoundments.

*** When an impoundment is converted to a tank, the disposition of the impoundment is assumed to be: idle, 10 percent; landfill closure, 60 percent; clean closure, 30 percent.

Figure 1
Assumed Distribution of Surface Impoundment Acreage by Compliance Method
(Number of Acres Out of Estimated Total of 3,811 Acres)



VI. Estimated Costs for U.S. Petroleum Refiners

The key estimates and assumptions necessary for estimating incremental compliance costs for the U.S. refining industry as a whole are listed in Table 6. A number of other assumptions used in these calculations should also be noted.

- O&M Costs:

ERM-Southwest's estimates of compliance unit costs and the percent distributions among compliance options for the various types of impoundments were used to develop estimated costs for U.S. petroleum refiners for the three regulatory scenarios. Most of the annual operation and maintenance (O&M) cost estimates provided by ERM are for new activities and therefore are incremental costs incurred under the legislative scenario assumptions. However, if an existing impoundment is closed and replaced by a steel tank or activated sludge tank, there may be a reduction in current operation and maintenance costs that should be credited against the additional tank operation and maintenance cost estimates provided by ERM. ERM provided no information on current impoundment O&M costs. It appears that O&M costs for impoundments are not easily separable from other costs but they are likely to be small relative to tank O&M costs. Therefore, the lack of an adjustment eliminating current O&M costs for impoundments that close under a regulatory scenario may lead to a small, but probably not significant over-estimation of costs for U.S. petroleum refiners.

- Impoundment Size:

Some of ERM's unit costs are on a per impoundment rather than per acre basis, but little information is available on the size of impoundments (the impoundment survey provided information on total impoundment acreage). Based on limited information provided by member companies, it was assumed that impoundments average four acres in size. As indicated in the sensitivity analysis section of this paper, the overall cost estimates are not sensitive to alternative assumptions regarding the average size of impoundments.

- Time Horizon and Discount Rate:

To estimate present values of refiners' expenditures and to put these expenditures on an annualized basis, a time horizon of 30 years and a real discount rate of 10 percent were used. The time horizon assumption sets the assumed average life of the new equipment (tanks, etc.) and the number of years of operating and maintenance costs included in the present value calculations. The impact of alternative time horizon and discount rate assumptions is assessed in the sensitivity analysis section.

Table 7 summarizes total initial and annual cost estimates, as well as present value and annualized cost estimates, for scenarios A, B, and C. Total costs estimated for all three legislative scenarios are substantial. Estimated initial costs, which include the cost of necessary equipment installation, range from about $3.4 billion for scenario A, to $3.7 billion for scenario B, to $5.5 billion for scenario C. Additionally, the regulatory scenarios also require expenditures for operation and maintenance of the installed equipment. Estimated operation and maintenance costs range from $117 million per year under scenario A, to $129 million per year with scenario B, to $190 million per year under scenario C.

These costs can be annualized and put on a present value basis using the assumed equipment lifetime and discount rate. Annualized costs range from $475 million to $772 million, well above the

Table 6

Cost Analysis Assumptions

Estimates/Assumptions	Source(s)	Table Summarizing Estimates/Assumptions
Industry Scale-up Factor	EIA U.S. refinery capacity data and API surface impoundment survey	Table 1
Compliance Option Distributions	ERM-Southwest report (based in part on legislative scenarios)	Table 5 (Tables 2 and 3)
Unit Costs of Compliance Options*	ERM-Southwest report	Table 4
Surface Impoundment Size: (4 Acres)	API	See Text
Present Value Assumptions: Life of Capital: 30 years Discount Rate: 10 percent	API	See Text

* Note: -Some of these costs are based upon assumed tank conversion factors.

$100 million mark that EPA would use to identify a "major" rulemaking requiring a regulatory impact analysis. On a present value basis, the estimated costs of regulatory scenarios range from about $4.5 billion for scenario A, to $4.9 billion for scenario B, to $7.3 billion for scenario C.

Figures 2 and 3 illustrate the major cost items (in terms of present values) by type of impoundment and by compliance method. In all three scenarios, clarifying, equalization and polishing (c/e/p) impoundments account for a large share of total costs, and contaminated stormwater impoundments also require significant expenditures. This is not surprising, given the distribution of surface impoundments presented in Table 1. The compliance options accounting for the largest shares of total costs are replacement of impoundments with regular tanks and using <MTR liners. This result is due to both the cost of these methods in relation to the costs of other methods as well as their frequency of use.

The change in the present value of costs from one regulatory scenario to another varies by type of surface impoundment. This reflects differing assumptions regarding the stringency of the scenarios across impoundment types, the costs of the compliance options, and the choices among compliance options.

Table 7

Estimated Costs to U.S. Petroleum Refining Industry Under Three RCRA Reauthorization Scenarios

Scenario	Cost ($ Million)			
	Initial	Annual	Annualized	Present Value
A	$3,377	$117	$475	$4,482
B	3,686	129	520	4,903
C	5,483	190	772	7,276

Note: Costs are estimated in 1992 constant dollars. Present values were calculated using a 10 percent discount rate and a 30 year time horizon. It was assumed that all initial costs occurred in year one, and that annual costs occurred in each year of the 30 year time horizon. The annualized cost is that amount which, if paid each year, would give a present value equal to the present value shown. The sensitivity of the present value calculation to alternative interest rate and time horizon assumptions is addressed in the sensitivity analysis section.

The percent increases in costs for the regulatory scenarios by impoundments types are as follows:

- Biological Impoundments
  - Scenarios A to B: 34.4 percent,
  - Scenarios B to C: 3.9 percent,
  - Scenarios A to C: 39.6 percent;

- Contaminated Stormwater, Settling Ponds, and Other Nonhazardous Impoundments
  - Scenarios A to B: 17.9 percent,
  - Scenarios B to C: 19.1 percent,
  - Scenarios A to C: 40.4 percent;

- Clarifying, Equalization, and Polishing Impoundments
  - Scenarios A to B: 0.0 percent,
  - Scenarios B to C: 80.0 percent,
  - Scenarios A to C: 80.0 percent.

Present Value of Refinery Costs
by Type of Surface Impoundment
C/E/P
4,484
2,491
2,491
Oth. Nonhaz.
542
455
386
Settl. Ponds
193
162
137
Cont. Stwtr.
1,501
1,260
1,069
Biological
556
535
398
Scenario C
Scenario B
Scenario A
$0
$1,000
$2,000
$3,000
$4,000
$5,000
Impoundment Type
$ Million

Figure 2

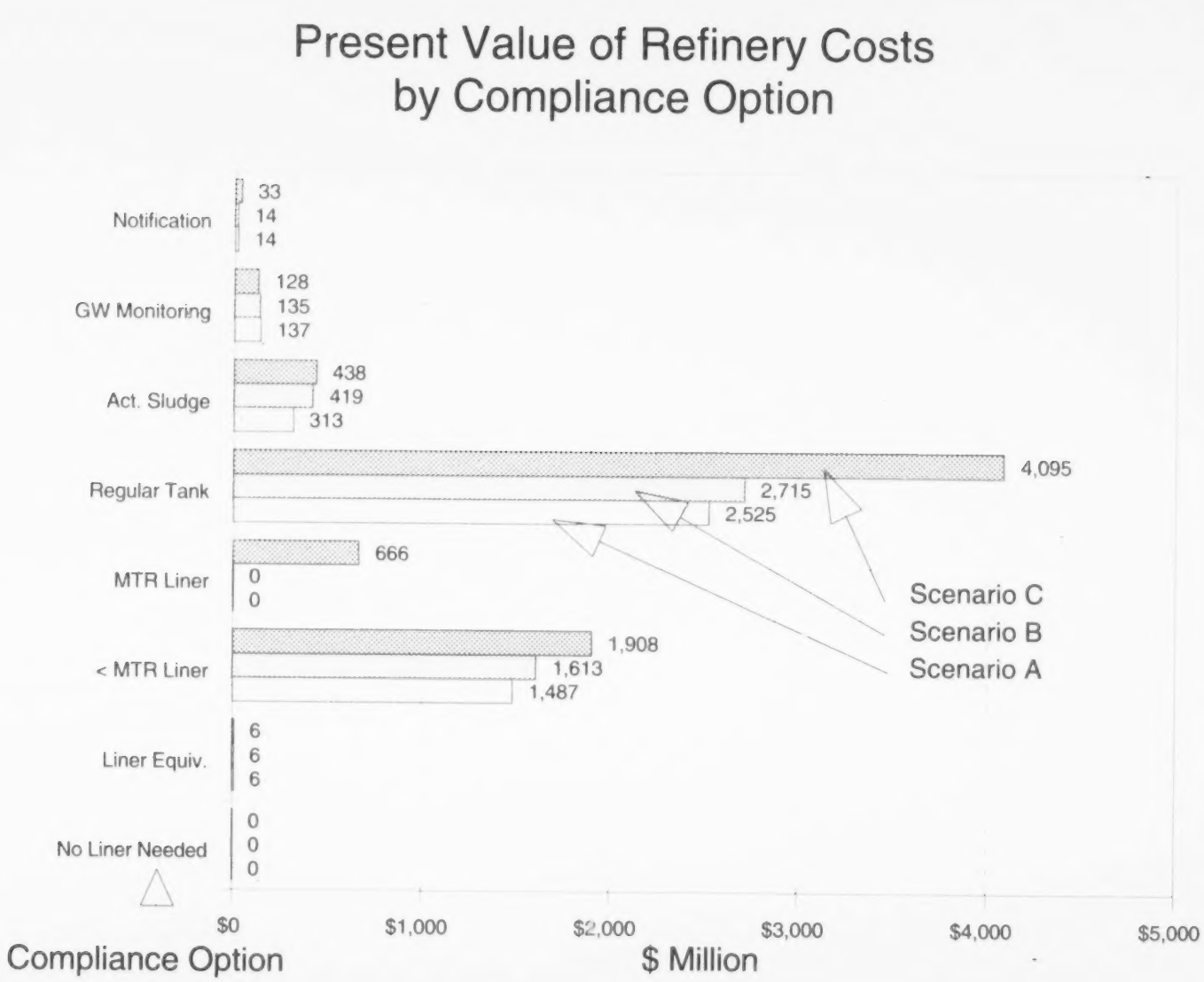

Present Value of Refinery Costs
by Compliance Option
Notification
33
14
14
GW Monitoring
128
135
137
Act. Sludge
438
419
313
Regular Tank
4,095
2,715
2,525
MTR Liner
666
0
0
< MTR Liner
1,908
1,613
1,487
Liner Equiv.
6
6
6
No Liner Needed
0
0
0
Scenario C
Scenario B
Scenario A
$0
$1,000
$2,000
$3,000
$4,000
$5,000
Compliance Option
$ Million

Figure 3

VII. Sensitivity Analysis

It can be useful to evaluate the sensitivity of cost estimates to alternative assumptions regarding various parameters. Such sensitivity analysis helps identify assumptions, unit cost items, choices among compliance options, or specific regulatory requirements that have a particularly large impact on estimated total costs to the industry.

The sensitivity of the surface impoundment cost estimates was evaluated by varying a number of factors. These fell into two categories: non-cost items and unit costs. *Non-cost items* include assumptions regarding surface impoundment size, industry scale-up factor, tank conversion factors, surface impoundment disposition, discount rate, and equipment life assumptions. *Unit cost items* refer to the costs of specific equipment items that could be used to comply with requirements under the scenarios

Tables 8 and 9 summarize the results of the sensitivity analysis.

- Impoundment Size:

Impoundment size was varied from the base case assumption of 4 acres to 2 acres and 8 acres. These relatively large changes (-50 percent and +100 percent) had only a small (4 percent or less) impact on estimated total costs.

- Refining Capacity:

Alternative assumptions regarding the appropriate total industry refinery capacity has a strictly proportional impact on estimated total costs. This is illustrated by measuring total refinery capacity as operating capacity only (16.4 million barrels per stream day) rather than the base case assumption of total (operating plus idle) capacity of 17.4 million barrels per stream day. The 6 percent reduction in assumed refinery capacity results in a 6 percent reduction in total estimated costs.

- Impoundment to Tank Conversion Factors:

Tank conversion factors were increased by 10 percent, implying that more tankage is required per acre of surface impoundment. The 10 percent increase in tank conversion factors resulted only in roughly 1 percent to 3 percent increases in estimated total costs.

- Impoundment Disposition:

Under the base case assumptions, it was assumed that when surface impoundments are replaced with tanks, 10 percent of the impoundments are idled, 30 percent are clean closed, and 60 percent are landfill closed. For the sensitivity analysis, percentages of 10, 40, and 50 were assumed, respectively. This alternative assumption resulted only in a 1 percent increase in estimated total costs.

- Annualized Costs and Present Values:

Changing the discount rate has the greatest impact on present value of costs of any assumption evaluated. Lowering the discount rate to 5 percent (from the base case assumption of 10 percent), raised the present value of total costs by 16 percent. Raising the discount rate to 15 percent lowered the present value of total costs by 7 percent. Shortening the time horizon from the base case assumption of 30 years to 20 years lowered the present value of total costs by 2 percent.

Tables 8 and 9 also indicate the sensitivity of estimated total costs to nine different unit cost categories. Ten percent increases in cost generally resulted in roughly 1 percent increases in the present

value of total industry costs. For <MTR liner and regular tank costs, 10 percent increases in costs resulted in roughly 3 percent to 4 percent increases in total industry costs.

Relative costs under the scenarios vary little as component parameters change. Under the base case assumptions, the scenario B costs were about 9 percent greater than scenario A costs, and scenario C costs were about 48 percent greater than scenario B costs. As parameters varied in the sensitivity analysis, the changes in the ratios of scenario to scenario costs were generally less than 2 percentage points.

Table 8

Sensitivity Analysis: Present Values of Total Industry Costs

Parameter	Present Value of Total Costs, by Scenario ($ Million) A	B	C
Base Case Assumptions:	$4,482	$4,903	$7,276
Non-Cost Items (Base Case Assumption):			
Surface Impoundment Size (4 Acres)			
2 acres	4,651	5,072	7,463
8 acres	4,397	4,819	7,182
Industry Refinery Capacity (Oper. + Idle)			
Oper. Capacity only	4,200	4,595	6,818
Tank Conversion Factors			
Regular Tank + 10%	4,621	5,053	7,502
Activated Sludge Tank + 10%	4,486	4,909	7,282
Surface Impoundment Disposition (10/30/60%)			
10/40/50%	4,548	4,976	7,382
Discount Rate (10%)			
5%	5,178	5,671	8,406
15%	4,147	4,534	6,732
Time Horizon (30 Years):			
20 Years	4,375	4,786	7,102
Unit Costs			
10% Increase in Unit Costs:			
Liner Equiv. Demo.	4,482	4,904	7,276
<MTR Liner	4,630	5,065	7,467
MTR Liner	4,482	4,903	7,342
Regular Tank	4,643	5,077	7,538
Activated Sludge Tank	4,504	4,933	7,307
Clean Closure	4,529	4,955	7,352
Landfill Closure	4,534	4,961	7,359
GW Monitoring	4,495	4,917	7,289
Notification	4,483	4,905	7,279

Table 9

Sensitivity Analysis: Percentage Changes in Costs From Base Case

Parameter	Percentage Changes in Total Costs, by Scenario A	B	C
Non-Cost Items			
Surface Impoundment Size			
2 acres (-50%)	+ 4	+ 3	+ 3
8 acres (+100%)	- 2	- 2	- 1
Industry Scale-up Factor			
Oper. Capacity only (-6%)	- 6	- 6	- 6
Tank Conversion Factors			
Regular Tank (+10%)	+ 3	+ 3	+ 3
Activated Sludge Tank (+10%)	< 1	< 1	< 1
Surface Impoundment Disposition			
10/40/50%	+ 1	+ 1	+ 1
Discount Rate			
5% (-50%)	+ 16	+ 16	+ 16
15% (+50%)	- 7	- 8	- 7
Time Horizon			
20 Years (-33%)	- 2	- 2	- 2
Unit Costs			
10% Increase in Unit Costs:			
Liner Equiv. Demo.	< 1	< 1	< 1
<MTR Liner	+ 3	+ 3	+ 3
MTR Liner	< 1	< 1	+ 1
Regular Tank	+ 4	+ 4	+ 4
Activated Sludge Tank	< 1	+ 1	< 1
Clean Closure	+ 1	+ 1	+ 1
Landfill Closure	+ 1	+ 1	+ 1
GW Monitoring	< 1	< 1	< 1
Notification	< 1	< 1	< 1

Note: Calculated from Table 8.

VIII. Conclusions

This analysis summarizes potential cost impacts of possible new legislative/regulatory requirements for managing refinery nonhazardous wastewater surface impoundments. This effort involved the development of three legislative/ regulatory scenarios, compilation of data on surface impoundments potentially impacted by the scenarios, assessment of alternative compliance mechanisms and costs, and assumptions regarding choices among the compliance options.

Based on the assumptions and information developed for the study, it was determined that potential new requirements on nonhazardous wastewater surface impoundments could result in significant compliance expenditures by refiners. Annualized costs for each of the three legislative scenarios are well above the $100 million mark that EPA uses to determine a "major" rulemaking. The present values of costs range from $4.5 billion to $7.3 billion, depending on the scenario.

As legislative requirements become more stringent, estimated compliance expenditures increase. The increase in costs from scenario B to scenario C is (proportionately) greater than the increase in costs from scenario A to scenario B.

Initial costs, as opposed to annual operation and maintenance costs, account for the majority of compliance expenditures that would be incurred. Clarifying, equalization and polishing impoundments account for a large share of total costs, and contaminated stormwater impoundments also require significant expenditures. The most costly compliance options are replacement of impoundments with regular tanks and using <MTR liners.

The analysis is somewhat sensitive to changes in the discount rate, the conversion factor for regular tanks, and changes in <MTR and regular tank unit costs. The analysis is insensitive to most of the other parameters tested, including surface impoundment size. In general, relative total costs in scenarios A, B, and C are not sensitive to changes in the parameters tested.

It should be noted that this analysis is static in nature in that it calculates the potential compliance cost to refiners, given the existing number of surface impoundments. ERM's unit cost estimates for compliance are necessarily based on existing technology. Assessing impacts of potential process changes by refiners, such as fundamental changes in wastewater generation and management, was beyond the scope of this analysis. In addition, the analysis does not address the extent to which costs might be passed on to consumers in the form of higher prices, or the subsequent impacts on overall product demand, refinery output, imports of refined product, employment, or other market variables. Finally, the economic analysis does not attempt to measure any potential environmental benefits of the assumed regulatory scenarios, or compare the value of any such benefits to the estimated costs of implementation.

APPENDIX A

RCRA Reauthorization Scenarios For New and Existing Nonhazardous Wastewater Impoundments

TABLE A-1

RCRA Reauthorization Scenarios* For New and Existing Nonhazardous Wastewater Surface Impoundments

A	B	C
o New Industry surface impoundments receiving nonhazardous contaminated wastewater would be subject to less than minimum technology design requirements (<MTR) such as minimum federal performance standards with regulations written and implemented by states, allowing some flexibility on the application of unit design specification for release prevention, based on hydrogeologic and climate conditions. An anticipated <MTR scenario could include: notification, site characterization including groundwater monitoring, single liner (natural clay) if appropriate, reporting, waste minimization/pollution prevention, financial assurance for corrective action, closure and post-closure.	o New industry surface impoundments receiving nonhazardous contaminated wastewater would be subject to notification, minimum technical design requirements (MTR-mandated double liners, leachate collection and groundwater monitoring) plus financial assurance for corrective action, closure and post-closure.	o All (new and existing) industry surface impoundments receiving nonhazardous contaminated wastewater (except existing clarifying, polishing and equalization ponds downstream of biological treatment; see below) would be subject to MTR, notification, financial assurance, and corrective action.
o Existing biological, clarifying, equalization, polishing, contaminated stormwater, settling, and other impoundments receiving nonhazardous contaminated wastewater would be subject to notification and groundwater monitoring only unless migration of contamination from the impoundment is detected and then: corrective action and <MTR requirements. It is assumed that where an impoundment has been completely removed through clean closure, no groundwater monitoring system will be installed.	o Existing biological, contaminated storm-water, settling, and other impoundments receiving nonhazardous contaminated wastewater (except clarifying equalization or polishing ponds downstream of biological treatment; see below) would be subject to <MTR performance standards as defined under Column A plus corrective action if migration of contamination from the impoundments is detected. o Existing clarifying, equalization or polishing ponds downstream of biological treatment would be subject to notification and groundwater monitoring only unless migration of contamination from the impoundment is detected and then: corrective action plus < MTR requirements.	o Existing clarifying, equalization or polishing ponds downstream of biological treatment only would be subject to <MTR performance standards as defined under Column A plus corrective action if migration of contamination from the impoundments is detected.

See notes at end of table.

TABLE A-1 (Continued)

RCRA Reauthorization Scenarios* For New and Existing Nonhazardous Wastewater Surface Impoundments

A	B	C
○ Impacted Facilities: New impoundments receiving contaminated wastewater (influent is not characteristic or listed hazardous waste) would meet flexible site-specific standards (i.e., <MTR requirements). Existing impoundments receiving contaminated wastewater (influent is not a characteristic or listed hazardous waste) would provide notification and conduct ground water monitoring only unless migration of contamination from the impoundment is determined then; corrective action and <MTR requirements.	○ Impacted Facilities: Impoundments receiving contaminated wastewater (influent is not a characteristic or listed hazardous waste) would meet either MTR, <MTR, or notification and groundwater monitoring depending on impoundment type and whether new or existing and if existing corrective action if migration of contamination is determined.	○ Impacted Facilities: Impoundments receiving contaminated wastewater (influent is not a characteristic or listed hazardous waste) would meet either MTR or <MTR depending on impoundment type and whether new or existing and if existing, corrective action if migration of contamination is determined.
○ Non-Impacted Facilities: Existing units exempted under RCRA's wastewater treatment exclusion (those meeting the RCRA definition of "tank"). New and existing impoundments receiving only uncontaminated influent (e.g., once through cooling water, uncontaminated stormwater, uncontaminated firewater).	○ Non-Impacted Facilities: Existing units exempted under RCRA's wastewater treatment exclusion (those meeting the RCRA definition of "tank"). New and existing impoundments receiving only uncontaminated influent (e.g., once through cooling water, uncontaminated stormwater, uncontaminated firewater).	○ Non-Impacted Facilities: Existing units exempted under RCRA's wastewater treatment exclusion (those meeting the RCRA definition of "tank"). New and existing impoundments receiving only uncontaminated influent (e.g., once through cooling water, uncontaminated stormwater, uncontaminated firewater).

NOTES:

* API's RCRA Reauthorization Coordinating Team oversaw the development of the legislative scenarios. There are an infinite number of possible scenarios. These represent three possible points within the spectrum in order to facilitate economic analysis.

TABLE A-2

Matrix of Regulatory Requirements For New and Existing Impoundments Under RCRA Reauthorization Scenarios

Type of Impoundments	New or Existing Impoundment	Scenario A		Scenario B		Scenario C	
		Migrated Contamination	No Migrated Contamination	Migrated Contamination	No Migrated Contamination	Migrated Contamination	No Migrated Contamination
Nonhazardous Contaminated Liquids (a)	New	<MTR, GWM, *CA, N	<MTR, GWM, N	MTR, GWM, *CA, N	MTR, GWM, N	MTR, GWM, *CA, N	MTR, GWM, N
	Existing	<MTR, GWM, *CA, N	GWM, N	<MTR, GWM, *CA, N	<MTR, GWM, N	MTR, GWM, *CA, N	MTR, GWM, N
Nonhazardous Contaminated Liquids Downstream of Biological (b)	New	<MTR, GWM, *CA, N	<MTR, GWM, N	MTR, GWM, *CA, N	MTR, GWM, N	MTR, GWM, *CA, N	MTR, GWM, N
	Existing	<MTR, GWM, *CA, N	GWM, N	<MTR, GWM, *CA, N	GWM, N	<MTR, GWM, *CA, N	<MTR, GWM, N

NOTES: (a) Includes Biological, Contaminated Stormwater, Settling Ponds and Other
(b) Includes Clarifying, Equalization, and Polishing
MTR = Minimum Technology Requirements
<MTR = Less Than MTR Requirements
GWM = Ground water monitoring
CA = Corrective Action
N = Notification
NA = Not Applicable
* Permits may be required for impoundments subject to corrective action, but correction action and associated requirements and costs are beyond the purview of this study.

APPENDIX B

Detailed Present Value Cost Estimates for Scenarios A, B, and C

Table B-1

Estimated Present Value of Industry Costs - Scenario A
(Millions of 1992 Dollars)

Compliance Method	Biological	Upstream Other than Biological: Contaminated Stormwater	Upstream Other than Biological: Settling Ponds	Upstream Other than Biological: Other Nonhazardous	Downstream: Clarifying, Equalizing & Polishing	Total
No Liner Needed	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Liner Equivalency Demonstration	0.3	1.1	0.1	0.4	4.0	6.0
<MTR Liner	28.7	385.6	49.5	139.3	883.4	1,486.5
MTR Liner	0.0	0.0	0.0	0.0	0.0	0.0
Regular Tank System:						
Installation	31.2	419.4	53.9	151.5	960.8	1,616.8
Impoundment Disposition:						
Idle	0.0	0.0	0.0	0.0	0.0	0.0
Landfill Closure	9.2	123.4	15.9	44.6	282.8	475.8
Clean Closure	8.3	112.2	14.4	40.5	257.0	432.4
Activated Sludge Tank System:						
Installation	225.5	0.0	0.0	0.0	0.0	225.5
Impoundment Disposition:						
Idle	0.0	0.0	0.0	0.0	0.0	0.0
Landfill Closure	45.9	0.0	0.0	0.0	0.0	45.9
Clean Closure	41.7	0.0	0.0	0.0	0.0	41.7
Groundwater Monitoring	6.7	24.3	3.1	8.8	93.8	136.8
Notification	0.8	2.6	0.3	0.9	9.6	14.3
Total	398.2	1,068.7	137.3	385.9	2,491.4	4,481.6

Note: Rows and columns may not total due to independent rounding.

Table B-2

Estimated Present Value of Industry Costs - Scenario B
(Millions of 1992 Dollars)

Compliance Method	Biological	Upstream Other than Biological: Contaminated Stormwater	Upstream Other than Biological: Settling Ponds	Upstream Other than Biological: Other Nonhazardous	Downstream: Clarifying, Equalizing & Polishing	Total
No Liner Needed	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Liner Equivalency Demonstration	0.3	1.1	0.1	0.4	4.0	6.0
cMIR Liner	40.1	462.8	59.5	167.1	883.4	1,612.9
MIR Liner	0.0	0.0	0.0	0.0	0.0	0.0
Regular Tank System:						
Installation	43.6	492.8	63.3	178.0	960.8	1,738.6
Impoundment Disposition:						
Idle	0.0	0.0	0.0	0.0	0.0	0.0
Landfill Closure	12.8	145.0	18.6	52.4	282.8	511.6
Clean Closure	11.7	131.8	16.9	47.6	257.0	465.0
Activated Sludge Tank System:						
Installation	302.1	0.0	0.0	0.0	0.0	302.1
Impoundment Disposition:						
Idle	0.0	0.0	0.0	0.0	0.0	0.0
Landfill Closure	61.5	0.0	0.0	0.0	0.0	61.5
Clean Closure	55.9	0.0	0.0	0.0	0.0	55.9
Groundwater Monitoring	6.2	23.8	3.1	8.6	93.8	135.4
Notification	0.8	2.6	0.3	0.9	9.6	14.3
Total	535.1	1,259.9	161.9	455.0	2,491.4	4,903.3

Note: Rows and columns may not total due to independent rounding.

Table B-3

Estimated Present Value of Industry Costs - Scenario C
(Millions of 1992 Dollars)

Compliance Method	Biological	Upstream Other than Biological: Contaminated Stormwater	Upstream Other than Biological: Settling Ponds	Upstream Other than Biological: Other Nonhazardous	Downstream: Clarifying, Equalizing & Polishing	Total
No Liner Needed	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Liner Equivalency Demonstration	0.3	1.1	0.1	0.4	4.0	6.0
<MTR Liner	0.0	0.0	0.0	0.0	1,908.2	1,908.2
MTR Liner	60.5	406.8	52.3	146.9	0.0	666.4
Regular Tank System:						
Installation	31.2	681.6	87.6	246.1	1,575.8	2,622.2
Impoundment Disposition:						
Idle	0.0	0.0	0.0	0.0	0.0	0.0
Landfill Closure	9.2	200.6	25.8	72.4	463.7	771.7
Clean Closure	8.3	182.3	23.4	65.8	421.5	701.3
Activated Sludge Tank System:						
Installation	315.7	0.0	0.0	0.0	0.0	315.7
Impoundment Disposition:						
Idle	0.0	0.0	0.0	0.0	0.0	0.0
Landfill Closure	64.2	0.0	0.0	0.0	0.0	64.2
Clean Closure	58.4	0.0	0.0	0.0	0.0	58.4
Groundwater Monitoring	6.2	22.3	2.9	8.0	88.9	128.3
Notification	1.8	6.1	0.8	2.2	22.4	33.3
Total	555.8	1,500.7	192.8	541.9	4,484.5	7,275.7

Note: Rows and columns may not total due to independent rounding.

Endnotes

1. Subtitle C TSD impoundments are already tightly regulated under RCRA.

2. The 17.4 million barrels per stream day capacity is total capacity, which includes capacity that was operating on January 1, 1992 as well as capacity that was idle on that date. Idle capacity was reported as about 1.1 million barrels per stream day. The sensitivity of cost estimates to different measures of total capacity is addressed later.

3. The legislative scenarios were developed through API's RCRA Reauthorization Coordinating Team.

4. The options and, subsequently the cost estimates, were reviewed by the API's RCRA Coordinating Team as well as API's Committee on Refinery Environmental Control to ensure that they were consistent with actual industry operating experience.

5. The timetable for meeting new legislative or regulatory requirements also would have a significant impact on costs. However, timing is not addressed in this analysis.

References

ERM-Southwest, Inc., *Study of the Economic Impacts on Refinering of Potential RCRA Reauthorization Requirements on New and Existing Industrial Solid Waste Surface Impoundments*, for the American Petroleum Institute, October 27, 1992.

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